Claims

Having thus described the invention, what is claimed is:

1. A method for scheduling the delivery of data packets representing one or more media data tracks, said method allowing the data packets to be delivered from a server to a client with a given bandwidth so as to minimize the initial delay required for the client to present the data without interruption, said method including the steps of:

creating a list of virtual data packets representative of all data packets to be scheduled for delivery from the server to the client;

calculating a delivery deadline for each virtual data packet based on the communications bandwidth from the server to the client;

sorting the list of virtual data packets based on the delivery deadlines calculated for each virtual data packet, to provide a sorted list; and

delivering the data packets in accordance with the sorted list.

2. The method of Claim 1 further comprising:

resolving temporal collisions between virtual data packets.

3. The method of claim 2, wherein the delivery deadline for each virtual data packet are calculated as

$$t(deadline) = t(start) - (packetsize)/(bandwidth)$$

where t(start) is the point in time when the client needs to act on the data contained in the packet, (packetsize) is the number of bytes in the corresponding data packet, and (bandwidth) is the communications bandwidth from the server to the client in bytes per second.

4. The method of claim 2, wherein the step of resolving temporal collisions is accomplished by comparing each virtual data packet in the sorted list of virtual data packets to the preceding

6 member of this list, starting with the member of this list having the latest delivery deadline and ending with the member of this list having the earliest delivery deadline.

5. The method of claim 2, said method including an additional step for removing temporal gaps between successive virtual data packets.

6. The method of claim 5, wherein the step of removing temporal gaps is accomplished by

12 comparing each virtual data packet in the sorted list of virtual data packets to the next successive member of this list, starting with a first member of the list having the earliest delivery deadline and ending with a last member of this list having the latest delivery deadline.

7. The method of claim 1 further comprising determining optimal client buffer size based on the communications bandwidth and communicating optimal client buffer size information to the client.

8. The method of claim 1 wherein the communications bandwidth varies, further comprising the

18 steps of:

determining a new communications bandwidth;

calculating a revised sorted list based on the new communications bandwidth;

replacing the sorted list with the revised sorted list; and

continuing delivery of packets according to the revised sorted list.

9. The method of claim 8 further comprising determining optimal client buffer size based on the new communications bandwidth and communicating the optimal client buffer size to the client.

6 10. A method for interleaving the data packets representing two or more media data tracks, said method allowing the data packets to be delivered from a server to a client with a given bandwidth so as to minimize the initial delay required for the client to present the data without interruption, said method including the steps of:

creating a list of virtual data packets representative of all data packets to be scheduled for delivery from the server to the client;

12   calculating delivery deadlines for each virtual data packet based on the communications bandwidth from the server to the client; and

sorting the list of virtual data packets based on the delivery deadlines calculated for each virtual data packet.

11. The method of Claim 10 further comprising:

resolving temporal collisions between virtual data packets.

18 12. The method of claim 11, wherein the delivery deadlines for each virtual data packet are calculated as:

$$t(deadline) = t(start) - (packetsize)/(bandwidth),$$

where t(start) is the point in time when the client needs to act on the data contained in the packet, (packetsize) is the number of bytes in the corresponding real data packet, and (bandwidth) is the communications bandwidth from the server to the client in bytes per second.

13. The method of claim 11, wherein the step of resolving temporal collisions is accomplished by

6 comparing each virtual data packet in the sorted list of virtual data packets to the preceding member of this list, starting with the last member of this list having the latest delivery deadline and ending with the first member of this list having the earliest delivery deadline.

14. The method of claim 11, said method including an additional step for removing temporal gaps between successive virtual data packets.

15. The method of claim 14, wherein the step of removing temporal gaps is accomplished by

12 comparing each virtual data packet in the sorted list of virtual data packets to the next successive member of this list, starting with the first member of this list having the earliest delivery deadline and ending with the last member of this list having the latest delivery deadline.

16. A method for determining the minimal initial delay required to deliver a sequence of data packets representing one or more media data tracks from a server to a client without interruption for a given bandwidth, said method including the steps of:

18   creating a list of virtual data packets representative of all data packets to be scheduled for delivery from the server to the client;

calculating delivery deadlines for each virtual data packet based on the communications bandwidth from the server to the client;

sorting the list of virtual data packets based on the delivery deadlines calculated for each virtual data packet into a sorted list; and

calculating the initial delay based on the size of the first data packet on said sorted list.

6 17. The method of Claim 16 further comprising:

resolving temporal collisions between virtual data packets.

18. The method of claim 17, wherein the delivery deadlines for each virtual data packet are calculated as

$$t(deadline) = t(start) - (packetsize)/(bandwidth)$$

where t(start) is the point in time when the client needs to act on the data contained in the 12 packet, (packetsize) is the number of bytes in the corresponding data packet, and (bandwidth) is the communications bandwidth from the server to the client in bytes per second.

19. The method of claim 17, wherein the step of resolving temporal collisions is accomplished by comparing each virtual data packet in the sorted list of virtual data packets to the preceding member of this list, starting with the last member of this list having the latest delivery deadline and ending with the first member of this list having the earliest delivery deadline.

18 20. The method of claim 18, wherein the minimum initial delay is determined by -t(deadline) for the first member having earliest delivery deadline of the sorted list of virtual data packets.

21. A method for determining the minimum size of each media data buffer required by a client to allow the client to receive a sequence of data packets representing one or more media data tracks from a server without interruption for a given bandwidth, said method including the steps of:

creating a list of virtual data packets representative of all data packets to be scheduled for delivery from the server to the client;

6 calculating delivery deadlines for each virtual data packet based on the communications bandwidth from the server to the client;

sorting the list of virtual data packets based on the delivery deadlines calculated for each virtual data packet into a sorted list; and

determining the maximum amount of data to be stored in the buffer as a function of time based the size of the virtual data packets and the delivery schedule from said sorted list.

12 22. The method of Claim 21 further comprising:

resolving temporal collisions between virtual data packets.

23. The method of claim 22, wherein the delivery deadlines for each virtual data packet are calculated as

$$t(deadline) = t(start) - (packetsize)/(bandwidth)$$

where t(start) is the point in time when the client needs to act on the data contained in the 18 packet, (packetsize) is the number of bytes in the corresponding real data packet, and (bandwidth) is the communications bandwidth from the server to the client in bytes per second.

24. The method of claim 22, wherein the step of resolving temporal collisions is accomplished by comparing each virtual data packet in the sorted list of virtual data packets to the preceding member of this list, starting with the last member of this list having the latest delivery deadline and ending with the first member of this list having the earliest delivery deadline.

25. The method of claim 22, wherein the step of resolving temporal collisions is followed by an additional step for removing temporal gaps between successive virtual data packets.

26. The method of claim 25, wherein the step of removing temporal gaps is accomplished by comparing each virtual data packet in the sorted list of virtual data packets to the following member of this list, starting with the first member of this list having the earliest delivery deadline and ending with the last member of the list having the latest delivery deadline.

27. A server-based system for scheduling the delivery of data packets representing one or more media data tracks and for thereby allowing the data packets to be delivered from the server to a client with a given bandwidth so as to minimize the initial delay required for the client to present the data without interruption, comprising:

at least one media database for storing multimedia data packets;

at least one media delivery component for delivering data packets; and

at least one ordering component for ordering the multimedia data into data packages for delivery, wherein said at least one ordering component comprises:

at least one virtual packet list component for creating a list of virtual data packets representative of all data packets to be scheduled for delivery from the server to the client;

at least one calculating component for calculating a delivery deadline for each virtual data

packet based on the communications bandwidth from the server to the client; and

at least one sorting component for sorting the list of virtual data packets based on the

delivery deadlines calculated for each virtual data packet, to provide a sorted list.

28. A program storage device readable by machine, tangibly embodying a program of

6 instructions executable by the machine to perform method steps for scheduling the delivery of

data packets representing one or more media data tracks, said method allowing the data packets

to be delivered from a server to a client with a given bandwidth so as to minimize the initial delay

required for the client to present the data without interruption, said method including the steps of:

creating a list of virtual data packets representative of all data packets to be scheduled for

delivery from the server to the client;

12 calculating a delivery deadline for each virtual data packet based on the communications

bandwidth from the server to the client; and

sorting the list of virtual data packets based on the delivery deadlines calculated for each

virtual data packet, to provide a sorted list.

at least one calculating component for calculating a delivery deadline for each virtual data

packet based on the communications bandwidth from the server to the client; and

at least one sorting component for sorting the list of virtual data packets based on the

delivery deadlines calculated for each virtual data packet, to provide a sorted list.

28. A program storage device readable by machine, tangibly embodying a program of

6 instructions executable by the machine to perform method steps for scheduling the delivery of

data packets representing one or more media data tracks, said method allowing the data packets

to be delivered from a server to a client with a given bandwidth so as to minimize the initial delay

required for the client to present the data without interruption, said method including the steps of:

creating a list of virtual data packets representative of all data packets to be scheduled for

delivery from the server to the client;

12 calculating a delivery deadline for each virtual data packet based on the communications

bandwidth from the server to the client; and

sorting the list of virtual data packets based on the delivery deadlines calculated for each

virtual data packet, to provide a sorted list.